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A METHOD OF MEASURING THYROID BURDEN OF I125.(U)
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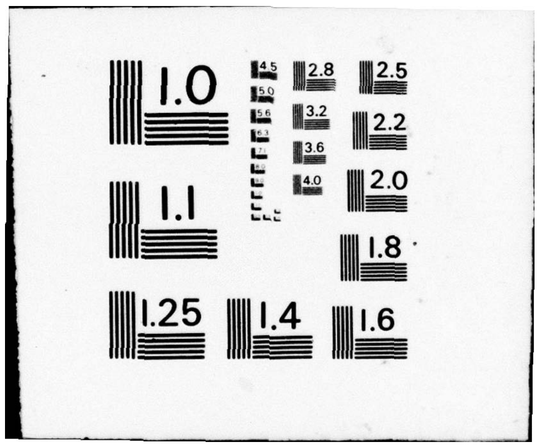
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A METHOD OF MEASURING THYROID BURDEN OF ^{125}I

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June 1976

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Laboratory workers producing ^{125}I labeled compounds may ingest or inhale small quantities of radioactive iodine which is deposited preferentially in the thyroid. Measurement of the thyroid burden is required to quantify the radiation dose to the individual and to provide early warning of possible health hazards. We ~~have developed~~ a rapid, accurate method of measuring thyroid burden using an Anger camera and pulse height analysis techniques. The procedure requires 2 to 3 minutes, over

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20. ABSTRACT (continued)

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equipment commonly available in a nuclear medicine department, and causes no discomfort for the subject. The minimum detectable amount of ^{125}I has been found ~~to be~~ ≃1.0 nCi with a counting time of 100 seconds. The linearity of the method has been measured using an ORINS thyroid phantom and sources traceable to the NBS. The method is in regular use at the AFRRI and some results obtained from this use are presented.

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PREFACE

The authors wish to thank G. J. Adler who contributed to the idea of using the gamma camera for measuring thyroid burden. Thanks also to H. E. Bourne and K. G. Mendenhall for their assistance in collecting the data, and special thanks to L. A. Slaback without whose prodding this paper would not have been written.

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INTRODUCTION

^{125}I is routinely used at the AFRRI in various experimental tasks. We have developed a method for measuring the thyroid burden of ^{125}I in personnel exposed during these procedures using an Anger type gamma camera as a detector of the Te x rays emitted at 27 and 31 keV[2] in the decay of ^{125}I. This detector system allows rapid measurement while retaining the capability of detecting nanocurie amounts of ^{125}I in the thyroid. We are thus able to accurately evaluate the thyroid burden of our personnel while causing a minimum of discomfort and inconvenience to the individual.

METHOD

The critical organ for ^{125}I uptake is the thyroid.[4] It has been shown[1] that within 2 days of exposure to ^{125}I, more than 95 percent of the total body burden is present in the thyroid. At any subsequent time, a measurement of the ^{125}I activity in the thyroid is a reliable indication of the final thyroid burden.

This activity was measured using a Searle Radiographics Pho Gamma HP scintillation camera. The summed energy pulse from the camera was routed to the input of the X ADC of a General Electric MED-II computer system which then functioned as a multichannel analyzer with a 256-channel conversion gain. A standard pinhole collimator was attached to the camera. The lead insert defining the pinhole was removed, leaving a collimator having an aperture 7.6 cm in diameter at a distance of 14.0 cm from the 25.4 x 1.3 cm NaI(Tl) crystal (Figure 1). It was necessary to retain some collimation because the camera was located in an operational nuclear medicine laboratory and the background observed with an uncollimated detector was unacceptably high. It was also observed that some subjects had surface contamination of ^{125}I on the face and hands. The collimator, which limited the field of view of the detector to the thyroid region, reduced the interference from this contamination.

The sensitivity of the system was measured as a function of vertical and lateral position using the 22-keV x ray from a point source of ^{109}Cd. A fit to

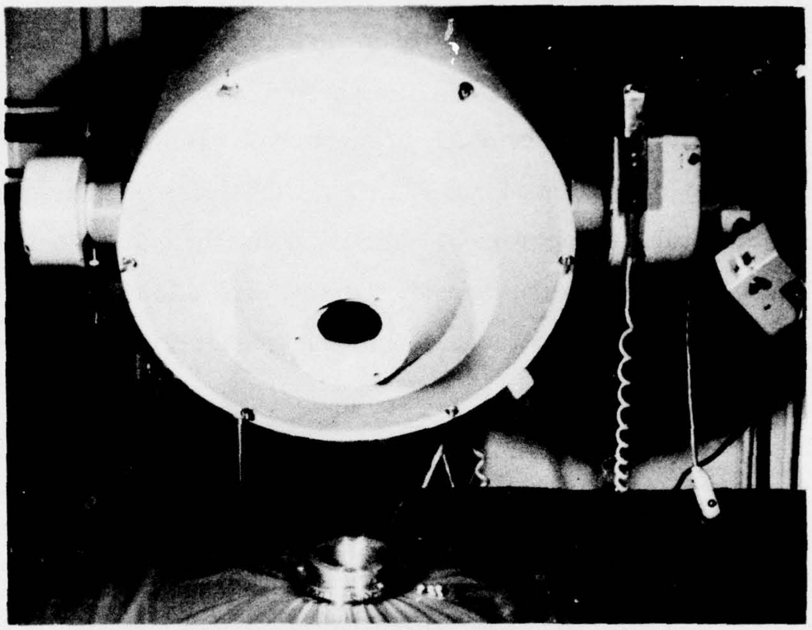

Figure 1. Camera with pinhole collimator attached and insert removed

these data was performed and isoefficiency curves were calculated in 10 percent increments as shown in Figure 2. From these data a source to collimator distance of 12.7 cm was chosen giving a range of sensitivities of $\pm$ 15 percent over the thyroid.

The correlation of observed count rate versus activity was measured as a further validation of the method. Three ^{125}I sources, having activities of 8.1, 8.8, and 118.8 nCi, were prepared using National Bureau of Standards calibrated standard reference materials (SRM-2030-74). An ORINS thyroid phantom was placed under the detector in the standard position and counted without the sources for 100 seconds to obtain a background. This procedure was repeated with each source in place, then with both lower acting sources in place in the phantom giving four observed count rates to correlate with the known activities. These data were subjected to linear regression analysis yielding a correlation coefficient of 0.99.

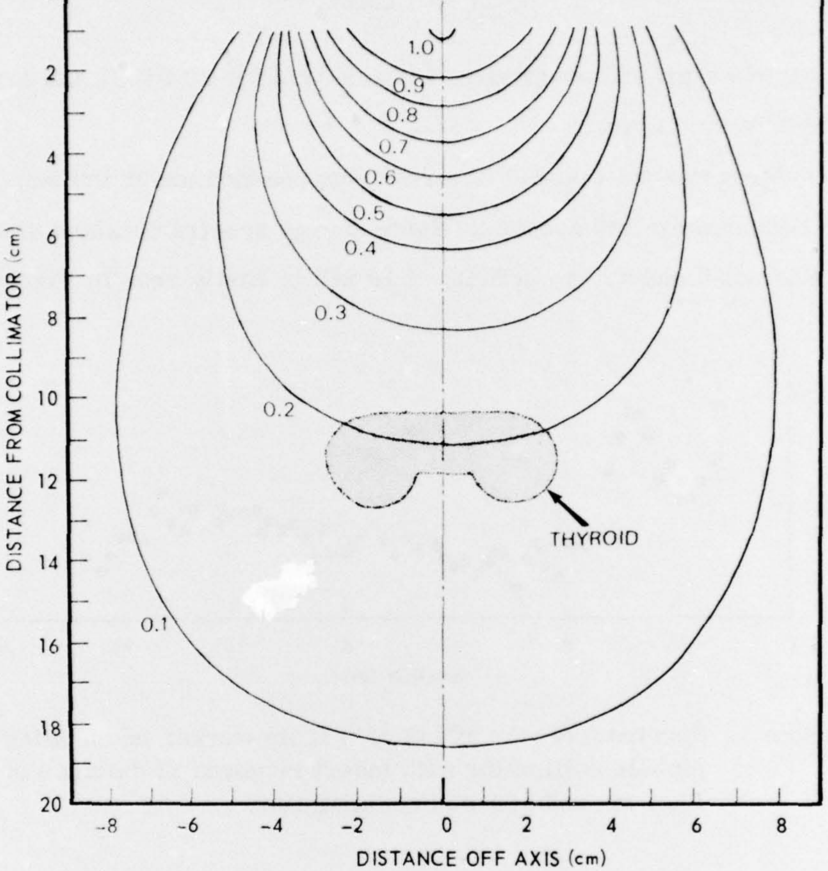

Figure 2. Relative efficiencies versus position for 22-keV x ray from a point source of ^{109}Cd

To insure the accuracy and reproducibility of the activity measurements, the following operations were performed each time the apparatus was prepared for use. Two ^{125}I standards were placed in the ORINS thyroid phantom, positioned at the predetermined source-detector distance, and counted for 100 seconds. A background measurement was obtained by removing the standards and repeating the counting procedure. After decay correction, the results of these two measurements were used to calculate the calibration factor in counts per minute per nanocurie, and the minimum detectable amount given by

$$\text{MDA} = \frac{3\sqrt{B/t}}{E}$$

where B is the background count rate, t is the counting interval, and E is the ratio of count rate to activity.

The subject was then placed in a reclining position under the detector assembly and counted for 100 seconds. Some energy spectra obtained are presented in Figures 3 and 4. An activity of 10 nCi is easily seen in Figure 3 and

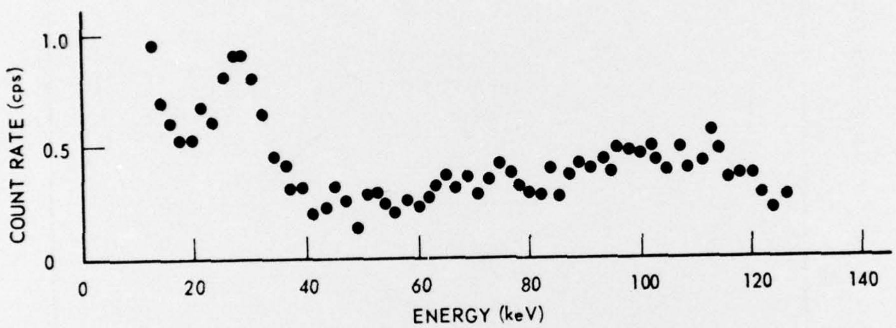

Figure 3. Spectrum of ~10 nCi of ^{125}I from worker taken using pinhole collimator with insert removed at distance of 11.4 cm and 100-sec counting time

the similarity of the spectrum from a human subject in Figure 3 and that from the phantom in Figure 4 provides some increased confidence in the calibration method. From spectra such as that in Figure 3, a thyroid activity may be calculated using

$$A = \frac{A_p}{P-B}\,(S-B)$$

where A is the ^{125}I activity in the subject, A_p is the ^{125}I activity in the phantom, P is the gross count rate of the phantom, B is the background count rate, and S is the gross count rate of the subject.

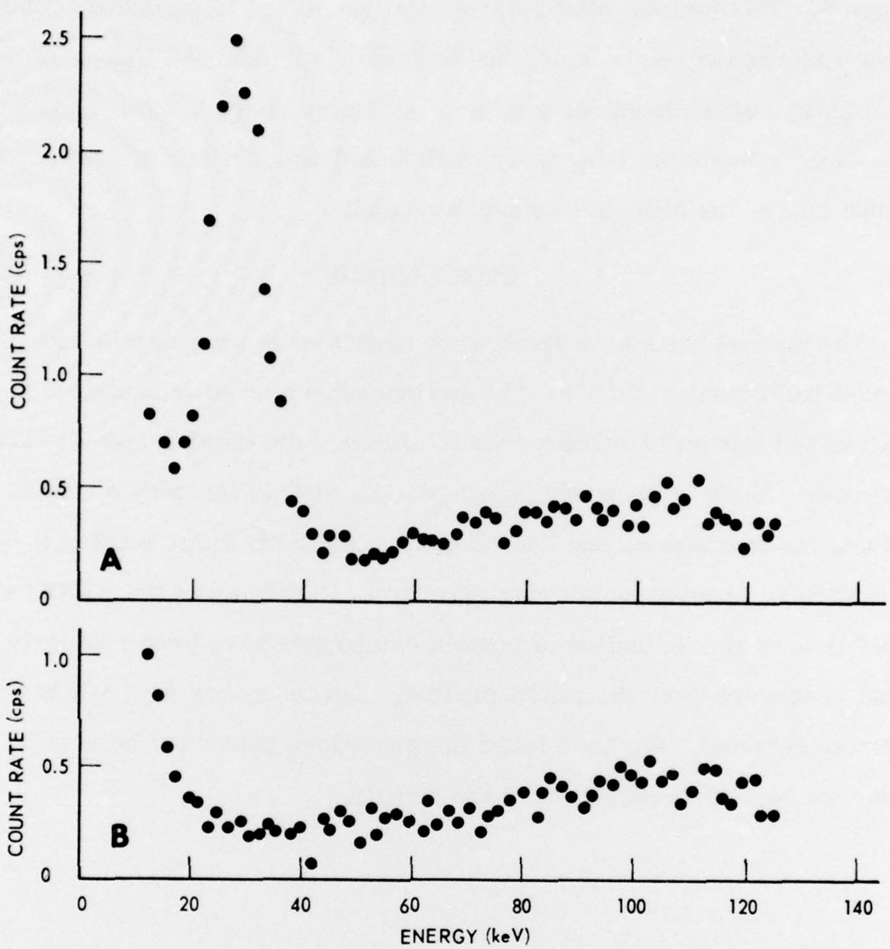

Figure 4. A. Spectrum of 30 nCi of ^{125}I in ORINS thyroid phantom at distance of 11.4 cm and 100-sec counting time. B. Typical 100-sec background with pinhole collimator insert removed.

EXPERIENCE

This system has been in use now for several months at the AFRRI. Minimum detectable amounts (MDA) as low as 1 nCi have been calculated for a 100-sec count. This value is considerably below the maximum permissible thyroid burden of 571 nCi (15 rad y^{-1})/(3.0 x 10^{-6} rad$\cdot$nCi$^{-1}\cdot$h^{-1} x 24 h$\cdot$d^{-1} x 365 d$\cdot$y^{-1}).[3] An alternate method of using the camera without any collimator was

attempted. This necessitated the use of a lead apron to shield the camera from scatter radiation from the body, and to reduce any contributions from low level contamination of the hands or clothing. However, variable radiation conditions in the nuclear medicine laboratory contributed significantly to background and at times raised the MDA to as much as 5 nCi.

CONCLUSIONS

The method has shown itself to be sensitive and precise for the determination of thyroid burden of ^{125}I. The equipment employed is available in many hospitals and medical facilities thus minimizing the capital outlay to begin such a program. More importantly, perhaps, the method involves a minimum of discomfort, inconvenience, and loss of time to the individual, making it practical to maintain an ongoing monitoring program. Personnel at the AFRRI who have participated in the iodination of protein compounds have been regularly checked by this procedure over the past 8 months. Levels as low as 2 nCi have been positively detected. We have found the procedure presented here to be a satisfactory one and will continue it at the AFRRI.

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